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- (21) Application No. 36208/73 (22) Filed 30 July 1973 (19)  
 (31) Convention Application No. 2 237 644  
 (32) Filed 31 July 1972 in  
 (33) Germany (DT)  
 (44) Complete Specification published 19 May 1976  
 (51) INT. CL.<sup>2</sup> B29F 1/00 1/06  
 (52) Index at acceptance  
 B5A 2M 3D12 3D1A 3D4B



# (54) IMPROVEMENTS IN OR RELATING TO INJECTION MOULDING MACHINES

(71) I, ERNST SAUERBRUCH, of 7702 Gottmadingen, Kreis Konstanz, Federal Republic of Germany, a German citizen, do hereby declare the invention, for which I pray that a patent may be granted to me, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to injection moulding machines.

In a known injection moulding machine for thermoplastics, thermosetting plastics material and elastomers, having an injecting unit associated with the mould and also having at least one mobile mould carrier plate or platen, for example, the magnitude of the injection pressure and the after-pressure (the pressure applied after the injection operation is finished or after the mould is filled) is set by hand by means of a pressure limiting valve in accordance with the type of moulding composition and the form of the moulded article. The dynamic pressure which is the pressure produced during the plasticising operation by the filling of the plasticising cylinder is controlled by an adjustable throttle, which presents a varying resistance to the outflow of the hydraulic fluid displaced by the plunger. The amount of the dosaging travel is fixed in dependence on the axial movement of the plasticising screw, being equal to the length of the return travel which the hydraulic cylinder carries out in the axial movement of the plasticising screw. A piston rod connected to the plasticising screw extends out of the cylinder and comprises a strip device which co-operates with a contact switch adapted to be displaced. Depending on the position of the contact switch, which limits the axial movement of the plasticising screw, the length of the dosaging travel can be varied. The temperature of the moulding composition can also be adjusted by known temperature control devices to a predetermined amount. The aforesaid parameters, therefore, are adjusted in accordance with the type of moulded article to a specific value which

they maintain at the same level in each individual working cycle. But in actual practice it may happen that for example the mass volume varies from shot to shot as a result of irregularities in the means preventing a return flow. The viscosity of the plasticised material may also vary in the individual working cycles. These irregularities cannot be corrected within the working cycles, and often result in the finished moulded articles varying from one another considerably in weight and quality.

According to one aspect of the invention there is provided a method of operating an injection moulding machine which includes the steps of monitoring the size of the relative movement in the opening sense which occurs between the mould halves at the end of an injection moulding cycle on account of the positive pressure developed in the mould and regulating for a subsequent moulding cycle in dependence on the magnitude of such relative movement at least one parameter selected from injection pressure, after-pressure, dynamic pressure, dosaging travel and cylinder temperature.

According to another aspect of the invention there is provided an injection moulding machine including monitoring means for monitoring the size of the relative movement in the opening sense which occurs between the mould halves at the end of an injection moulding cycle on account of the positive pressure developed in the mould and regulating means for regulating for a subsequent moulding cycle in dependence on the magnitude of such relative movement at least one parameter selected from injection pressure, after-pressure, dynamic pressure, dosaging travel and cylinder temperature.

The amount of this mould opening movement can be measured by known mechanical, electrical, electro-mechanical, hydraulic or pneumatic measuring devices. The measuring device is generally connected by a control line to a control device and the latter is connected to the particular part, for example an infinitely variable pressure limit-

ing valve, whereby the corresponding parameter, for example the injection pressure and/or the after-pressure (or held pressure), can be varied when a specific tolerance range is exceeded or gone below. The amount of this tolerance range within which the control of the part does not respond to mould opening movements, can be predetermined.

In a preferred form of injection moulding machine, in order to measure the spacing between the two mould carrier plates, there is arranged at the mobile mould carrier plate a measuring rod which co-operates with a measuring device secured to the machine frame.

Using the invention it is possible automatically to so regulate the parameters which determine the quality of the moulded articles that they are in their optimum setting at each working cycle. If any irregularity takes place within a working cycle, for example if excessive injection takes place, the result is a greater opening movement of the mould at the end of the injection operation. At the same time with this greater opening movement for example the dosaging travel for the next working cycle is reduced, so that less moulding material enters the mould and excessive injection into the mould is prevented in the next working cycle. The parameters: injection pressure, after-pressure, dynamic pressure, dosaging travel and cylinder temperature can thus always correct themselves towards their optimum. The result is greater uniformity of moulded articles as regards shape, weight and quality. The preselectable magnitude range of the mould opening movements within which no regulation of the parameters takes place, avoids having too sensitive a system. Since regulation takes place only if this tolerance range is exceeded or gone below, automatic optimising of the set parameters is achieved.

A preferred embodiment of the invention will now be described, by way of example only, with reference to the accompanying drawing.

The diagrammatic drawing shows an injection moulding machine having a mould 1 whose mould half 2 is secured on a mobile mould carrier plate 3 and the other mould half 4 on the machine frame 5. The mobile mould carrier plate 3 is driven by hydraulic pistons 6 guided in clamping cylinders 7. The mould 1 has associated therewith an injection unit 8 with a plasticising and injecting screw 9. The plasticising and injecting screw 9 can be displaced axially by a hydraulic piston 10 which is guided in a cylinder 11.

The injection moulding machine comprises a distance measuring device for measuring the spacing A between the mould carrier plate 3 and the machine frame 5.

The spacing measuring device consists of a measuring rod 12 which is arranged on the mobile mould carrier plate 3 and co-operates with a measuring head 13 secured on the machine frame 5. From the measuring head 13 a control line 14 leads to a control device 15 which is connected to an infinitely variable pressure limiting valve 16. The pressure limiting valve 16 is arranged in connection with a pressure conduit 17 leading from a pump 18 to the cylinder 11. Before the entry of the pressure conduit 17 into the cylinder 11 there is arranged a hydraulic valve 19 whereby the beginning and end of the axial displacement of the injecting screw 9 are initiated.

The apparatus provided by the invention operates as follows:

By introducing hydraulic fluid into the clamping cylinders 7, the mould 1 is closed and held shut with a constant pressure. At the same time the distance measuring device 12, 13 is actuated by closing a circuit. To initiate the injection operation, the hydraulic valve 19 is opened and the injecting screw 9 is displaced axially in the injection direction. As soon as the mould cavities are filled a positive pressure is produced which tends to open the mould. The mobile mould half 2 is moved by fractions of a millimetre in the opening direction. The amount of this opening movement is measured by the distance measuring device 12, 13 and transmitted to the control device 15. The control device 15 can be a commercially obtainable electronic unit with an adjustable tolerance range corresponding to a specific allowable distance variation range of the mould halves, and within the limits thereof the injection pressure is kept to an optimum constant value. As long as the distance variation is within these given limits, the injection pressure does not change. But if the mould opening movement is smaller than the lower limits of the tolerance range, this is a sign that the injection pressure is set too low. The control device 15 in this case regulates the pressure limiting valve 16 for the next working cycles to a higher injection pressure. If the tolerance range is exceeded, on the other hand, the injection pressure is regulated in inverse proportion to the mould opening movement. Owing to the greater mould opening movement, the measuring head 13 by way of the control line 14 and the control device 15 sets the pressure limiting valve 16 to a lower value for the next working cycles. This is also true in the same way for the control of the after-pressure. The dynamic pressure produced during plasticising can be controlled also by operating an adjustable dynamic pressure throttle (not shown) associated with the cylinder 11. As a result a varying viscosity is achieved for the plasticised composition.

The amount of the dosaging travel also determines the degree of filling of the mould. A considerable opening movement of the mould points to an excessive dosaging travel. From the measuring head 13, a closing valve (not shown but, arranged for example before the said throttle) is operated and the instant at which the valve closes can be modified. At the next working cycle, the dosaging travel is then shortened owing to the earlier closing time, and thus the degree to which the mould is filled is reduced.

It is also possible in this way to influence the temperature of the moulding composition or its viscosity. The heating of the plasticising cylinder can be regulated by a temperature control device connected by way of a control line to the measuring head of the distance measuring device.

#### WHAT I CLAIM IS:—

1. A method of operating an injection moulding machine which includes the steps of monitoring the size of the relative movement in the opening sense which occurs between the mould halves at the end of an injection moulding cycle on account of the positive pressure developed in the mould and regulating for a subsequent moulding cycle in dependence on the magnitude of such relative movement at least one parameter selected from injection pressure, after-pressure, dynamic pressure, dosaging travel and cylinder temperature.

2. A method according to claim 1 conducted substantially as herein described and exemplified.

3. An injection moulding machine including monitoring means for monitoring the

size of the relative movement in the opening sense which occurs between the mould halves at the end of an injection moulding cycle on account of the positive pressure developed in the mould and regulating means for regulating for a subsequent moulding cycle in dependence on the magnitude of such relative movement at least one parameter selected from injection pressure, after-pressure, dynamic pressure, dosaging travel and cylinder temperature.

4. An injection moulding machine according to claim 3, in which said monitoring means comprises a mechanical, electrical, electro-mechanical, hydraulic or pneumatic measuring device for measuring said relative movement, and in which said regulating means comprises a control device connected by a control line to said measuring device and adapted to vary said parameter when said relative movement has a value below or above a specific tolerance range therefor.

5. An injection moulding machine according to claim 3 or claim 4, in which said monitoring means comprises a measuring rod attached to the movable mould carrier plate and a measuring head adapted to co-operate with said measuring rod and fixed to the frame of said machine.

6. An injection moulding machine constructed and arranged substantially as herein described and as illustrated with particular reference to the accompanying drawing.

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COMPLETE SPECIFICATION

1 SHEET

*This drawing is a reproduction of the Original on a reduced scale*

